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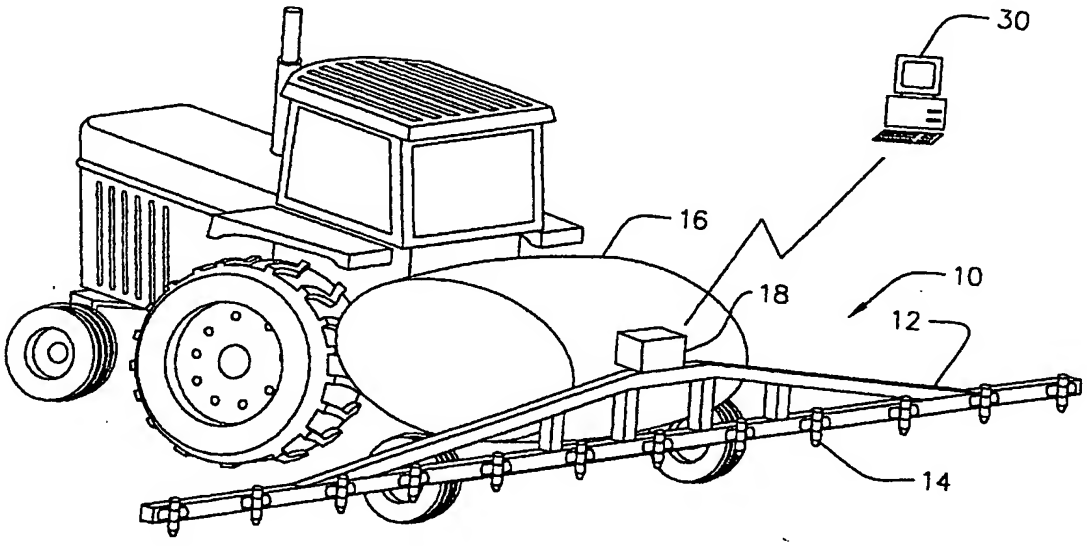
(54) Title: APPARATUS AND METHOD FOR WIRELESS MONITORING AND CONFIGURATION OF A MOBILE SPRAYING SYSTEM



(57) Abstract: A wireless networked spray application system includes a base station (30), one or more remote electronic spray controllers (18) adapted to control spraying equipment, and a wireless communication link (32) between the base station (30) and the electronic spray controllers (18). The base station (30) preferably includes a central processing unit that works in accordance with an operating program to present a graphical user interface. This permits a user to create control instructions for operating the spray controllers (18) and download data from the spray controllers (18), monitor the operation of the spray application equipment, execute control programs in accordance with the spray controller program data, and receive and store summary information of the monitored spray application equipment.

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APPARATUS AND METHOD FOR WIRELESS MONITORING AND CONFIGURATION OF A MOBILE SPRAYING SYSTEM

FIELD OF THE INVENTION

This invention generally relates to mobile spraying systems and control electronics. More particularly, this invention concerns apparatus and methods for remotely monitoring, configuring and/or controlling mobile spraying systems from a base station.

BACKGROUND OF THE INVENTION

Spraying systems are used to apply liquid and/or solid bulk material over large surfaces such as agricultural fields, highways or the like. Such materials are typically dispensed under liquid pressure, through gravity flow or other suitable discharge methods. Early spraying systems, however, were crudely controlled. Spray nozzle orientations and spray discharge rates were required to be manually adjusted. Accordingly, precise application of the material was not generally expected or achieved.

Today, spraying systems have evolved and now deliver precise amounts of material in precise application patterns. The improved precision of these systems enables material application efficiencies to be achieved. This has resulted in cost and material savings in such endeavors as maintaining agricultural crops and roadways. For example, a ten percent reduction in the use of a chemical on a twice sprayed 1000 acre farm may represent a cost savings to a farmer of between $2,000-$10,000 annually based on typical chemical investments of $10.00 to $50.00 per acre. Further value is added due to less crop damage and loss. The environmental benefits resulting from the reduced material application and increased efficiency is also substantial.

The improved spray systems utilize electronic controls which operate in accordance with user entered configuration information. Typically, these systems include a spray controller mounted on the spray application equipment that

executes input configuration information in accordance with a control program installed on the spray controller. Typically, the controller includes a control console that is disposed to receive manual input of information concerning the desired application rate and pressure parameters. In operation, the spray controller monitors such operating parameters of the system as flow rate, system pressure and ground speed. The controller uses these data to provide output signals to regulate system pressure and control the discharge in a main line regulating valve. For providing user information, the control console displays such information as actual sprayer speed, target application rate and system operating pressure. In addition, the console may display such information as actual application rate, field area covered and tank volume.

For reducing the configuration time, card readers are sometimes utilized in conjunction with these spray controllers. This speeds up the process of configuring and/or programming the spray controller and enables data transfer between the spray controller and data processing equipment. However, the operator of the equipment must be familiar with card reader technology being utilized and must use the correctly encoded cards at the equipment location for programming the application controller in the intended fashion. More importantly, the use of card readers does not provide adequate flexibility under various operating conditions.

Once the system is programmed and operating in the field or highway, the spray controller electronics also provides useful feedback to the operator of the spraying equipment. For example, the operator may receive information obtained by application sensors and electronics concerning the flow rate of materials through the system and the speed of the vehicle applying the materials. From these and other variables and characteristics of the system, the spray controller determines an overall spray application density (e.g., gallons/acre) of the material being applied, which may also be monitored by the equipment operator. The need, however, exists to enable the real-time monitoring of such data by personnel other

than the equipment operator such that corrective action may be taken when appropriate.

SUMMARY OF THE INVENTION

The general aim of the present invention is to provide a new and improved spraying system and control electronics for such a system which permits remote monitoring and control of the spraying system.

It is a more particular object to improve programming and/or monitoring capabilities of an agricultural spraying system from a remote station.

It is a further object of the present invention to enable a communication link between spraying or material application equipment and a remote station prior to, and/or during, operation of the equipment in order to program and/or monitor the equipment from the remote location.

Still another particular object is to improve data acquisition and data transfer capabilities between an electronic controller and a remote computer in a spraying application.

It is yet another object of the present invention to improve the process of downloading information from one or more electronic controllers to a base computer for archiving, analysis, validation, and other data processing and management operations. These and additional objects and advantages will be more readily apparent upon consideration of the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

The appended claims set forth the features of the present invention with particularity. The invention, together with its objects and advantages, may be best understood from the following detailed description taken in conjunction with the accompanying drawings of which:

Fig. 1 illustrates an agricultural spraying system according to one embodiment of the present invention;

Fig. 2 is a high level schematic block diagram illustrating various components of the spraying system of Fig. 1 including a wireless communication link;

Fig. 3 is a block diagram illustrating the flow of information between a base computer connected through wireless communication to an electronic controller of the spraying system in accordance with one embodiment of the present invention;

Fig. 4 is a summary of the logical steps performed by the base computer in a typical material application job carried out by a system incorporating the present invention;

Fig. 5 is an exemplary graphical user interface displayed by a base computer during the programming stage for a material application job; and

Fig. 6 is an exemplary graphical user interface displayed by a base computer during the monitoring stage for a material application job.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS OF THE INVENTION

The above and additional objects and advantages are achieved with a wireless networked spray application system and method for operating that system. The system is implemented with a base station, one or more remote electronic spray controllers adapted to control spraying equipment, and a wireless communication link that is established between the base station and at least one of the electronic spray controllers. The base station preferably includes a central processing unit that functions in accordance with an operating program to present a graphical user interface. This permits a user to easily create control instructions that may be downloaded to a spray controller for operating the same. In addition, the base station may download data from the spray controllers, monitor the operation of the spray application equipment, execute control programs in accordance with received spray controller program data, and receive and store summary information of the monitored spray application equipment.

Fig. 1 illustrates an exemplary environment in which the present invention may be utilized. As shown, an agricultural implement such as a sprayer 10 includes a transversely oriented boom 12 with a plurality of spaced spray nozzles 14 depending therefrom. Spray material such as a mixture of chemical fertilizer and water is pumped from a vessel or tank 16 through a main fluid line (not shown). The spray material is distributed in a known manner such as through branch lines to each of the nozzles 14. Fluid is discharged from the nozzles 14 at prescribed spray application rates under the control of a spray controller 18, as will be described in greater detail below. The agricultural sprayer 10 is operated in a known manner such as by a tractor or other suitable vehicle in order to apply liquid spray to the area intended to be sprayed. Of course, other suitable material application equipment may be utilized in conjunction with the invention.

Fig. 2 shows a high level block diagram that schematically depicts primary components of the material application system incorporating the present invention. The spray controller 18 is adapted to receive sensing signals from a flow meter 20 for monitoring the liquid flow in the main fluid line. In addition, the spray controller 18 receives input signals from a pressure monitoring device such as a pressure transducer 22. The pressure transducer 22 provides information based on the sensed pressure in the main fluid line. The spray controller also receives input signals from a speed sensor 24 which detects the ground speed of the sprayer. In one embodiment, the spray controller 18 operates in a logical fashion, based on these signals, to provide an output signal to a pressure regulating valve 28 for controlling the flow of liquid in the main fluid line.

In addition, the spray controller 18 provides actuating signals to the plurality of spray nozzles 14. For example, the spray nozzles 14 may include a solenoid controlled actuating valve as will be understood by those skilled in the art. In response to such actuating signals, the nozzles 14 operate to apply a desired spray discharge pattern at a desired application rate. The spray controller 18 may alternatively be configured to receive location information from a location sensor

26, although such information is not necessary for the operation of spray controller in the preferred embodiment.

The spray controller 18 is a microprocessor-based device with sensor inputs for sensing operating parameters of a material application assembly and vehicle. As indicated above, the operating parameters may include, for example, vehicle speed, spray system pressure, material flow rate and vehicle location. Such parameters are sensed for example, in a known manner, by speed sensor 14, pressure transducer 16, flow meter 18, and global positioning system 20. The above list of sensors is exemplary as those skilled in the art will understand that additional sensor inputs may be desirable and that many types of alternative sensing devices may be used (such as a radar for determining speed) in other embodiments of the present invention. It is also noted that while the sensors are configured in the present embodiment to apply to all the spray nozzle assemblies, in alternative embodiments of the invention, the operation of the nozzle assemblies is observed on an individual basis to improve the ability of operators to detect and isolate malfunctioning equipment.

The spray controller 18 thus controls application rate based on the density of material, the flow rate of material and the area coverage rate by adjusting the output signals to ensure proper application of material via the spraying system. For example, if the application density needs to be increased, then the material flow rate is increased based on a constant ground speed. This adjustment is performed either manually by an operator, or automatically by the material application controller 18 as part of a closed loop process including obtaining sensor input, calculating present operation parameters, comparing the operating parameters to desired set points, and generating output control signals for maintaining the operation of the application equipment at the desired set points. The resulting system will ensure proper application of materials and result in lower costs to the operator. Proper application will also guard against loss and damage to crops or property resulting from application of the material at an improper rate.

In accordance with the invention, a base station includes communication interface software and procedures for enabling a user to remotely carry out a set of configuration, maintenance, monitoring and/or management tasks associated with the spray controller and material application system. Such tasks include creating material application system program data, downloading the program data from the remote station to the spray controller 18, monitoring telemetry information as it is received by the spray controller 18 during operation of material application hardware in the field, and storing summary information received from the material application controller upon completion of a job.

For performing these and other functions, a base computer 30 is provided. The base computer 30 operates to initiate program updates to the operating software within the spray controller 18 as new versions are released. In accordance with a particular aspect of a preferred embodiment of the invention, discussed further herein below, the base computer 10 incorporates a graphical user interface motif facilitating execution by a user of the configuration, maintenance, monitoring and management tasks by executing graphical user interface commands (e.g., point and click, tabbing through fields, selections from lists, roll-up/roll-down value selection).

While the base station 10 is implemented in this preferred embodiment as a personal computer, those skilled in the art will appreciate that the base computer may also be implemented on any CPU or platform ranging from embedded environments to general computing platforms. Similarly, the base station may be employed to control a plurality of spray controllers for one or more tasks.

In keeping with the invention, the base station and the spray controller are communicatively linked and exchange application program data and operation data via a wireless communication link. The wireless communication link includes a wireless base computer transceiver communicatively coupled to the base computer and a wireless spray application controller transceiver communicatively coupled to the spray application controller. Wireless communication via the link provides a convenient, flexible communications path between the base computer and the

application controller. The computationally intensive task of programming the controller and real-time monitoring of application parameters during operation of a spraying system can be accomplished remotely at the base computer.

In one preferred embodiment, the base computer 30 and the spray controller 18 communicate via a wireless communication link 32. The base computer 30 is communicatively coupled to a base transceiver 34 of the wireless communication link 32. The base transceiver 34 preferably communicates locally with the base computer 30 via well known cable and interface hardware (e.g., RS232). A spray controller or remote transceiver 36 is communicatively coupled to the application controller 18 via known interface cable and interface hardware as well. In one preferred embodiment of the invention, the transceivers 34 and 36 are implemented as wireless modems such a modem from the "Hopper" family of modems manufactured and sold by WiLan Wireless Data Communications, 300, 801 Manning Rd. N.E., Calgary, Alberta, Canada T2E 8J5. It is noted, however, that other modem devices or wireless communication devices may also be used. For example, the wireless transmission media may be implemented through cellular telephony links and/or may also include communication through Internet linkages enabling the base computer 30 and spray controller 18 to be located, and communicate from positions virtually anywhere in the world.

The wireless communication link 32 enables many of the time consuming and complex configuration tasks for the application controller 18 to be accomplished by skilled personnel from the base computer 30 having a large, user friendly graphical user interface. The programming and downloading occurs within the comfort of a central office location. Such personnel need not transport bulky computer hardware and attach cables to the spray controller 18 and base computer 30 to accomplish the programming function. Printing of operation data takes place from the base computer 30 via conventional printers rather than special purpose, and therefore more costly, printers attached to the application controller data interface. The wireless communication link 32 also enhances monitoring of spray operations by non-operators since the operation data can be accessed without

connecting cables or bringing additional computer hardware to the field to download information stored in the material application controller 18.

It is further noted that the embodiment disclosed in Fig. 2 shows only a single base computer 30 and a single application controller 18. However, it is contemplated that in alternative embodiments of the invention, the base computer 30 will communicate with a number of application controllers. Appropriate naming and addressing schemes are incorporated into such embodiments to ensure that a proper spray controller is connected via the wireless link at any particular time. Such a system enables a expert to program various spray controllers from a central location without having to actually travel to the location of the application equipment to program the application controller and monitor its subsequent operation.

Fig 3 is a schematic diagram depicts the flow of information between the base computer 30 and the material application controller 18 via the wireless telecommunications link 32. Application instructions/information 40 for a specific job are entered by a programmer at the base computer 10. Application instructions/information 40 typically include an identification of customer name and location, materials to be applied and the density at which the identified materials are to be applied for a particular task. Other information such as vehicle speed and material flow rate are entered or calculated from other entered operating parameters. The resulting application program data for the specified job, which preferably is a subset of the application instructions/information 40 generated in response to entry by the user, is then transmitted by the base computer 30 to the application controller 18 via the wireless link 32.

The received data is stored as application program instructions 42 in local memory resident in the spray controller 18. In the preferred embodiment, the local memory can be volatile and/or nonvolatile data storage. It possesses sufficient capacity for storing application programs for several jobs. The application instructions/information 40 are also preferably stored at the base computer 10 for later reference. The spray controller 18 later retrieves the application program

instructions 42 from the local memory during a later performed material spraying operation.

For application of material during a spraying operation, the spray controller 18 executes control programs in accordance with the application program parameters for a particular job retrieved from program instructions 42 and operating software 44. The operating software 44 is a template having slots filled by the specific data contained in a selected application program from the set of programs stored in the application program instructions 42.

The application controller 18 receives and processes telemetry data from the set of sensors 20, 22, 24, and 26, a summary set of which is stored in a telemetry data storage 46. The telemetry data from storage 46 is used in a number of ways. First, the data is periodically provided to the spray controller 18 to provide feedback and possibly activate warnings in the event that the application of material is not following the pre-set requirements set forth in a currently executing material application specification loaded into the spray controller 18 from the application program instructions 42.

Second, the telemetry data from storage 46 is transmitted in real-time during the operation of spraying system, via the wireless communications link 32, to the base computer 30. The transmitted data is stored in a diagnostic information storage 48 and referenced by a technician during the operation of the spraying operation to detect, diagnose, and possibly remedy malfunctions of the application equipment.

Third, over a longer period of time, summary data regarding the operation of the material application equipment is stored in the telemetry data storage 46. The data for one or more material application operations is transferred via the wireless data communications link 32 to the base computer and stored in the diagnostic information storage 48. Thereafter, the stored application summaries can be processed to detect trends in the operation of the equipment and possibly spot gradual degradations in the performance of the equipment that might go unnoticed by the operator on any particular job. Such data transfers are

accomplished with minimal effort on the part of the operator and may be accomplished by a mere point and click or other appropriate action on a graphical user interface of the base computer.

Turning now to Fig. 4, the steps are summarized for carrying out a typical material application operation utilizing a system embodying the present invention. At step 100, an operator creates an application program by entering material application parameters of the type mentioned, without limitation, above. These parameters define the mission critical as well as the optional information for operating the material application equipment for a particular job. This operation can be performed anywhere a personal computer or other computer is available with a suitable programming software for entering the operating parameters. An important feature is that the application controller need not be at the location where the program is created.

At step 102, the application program, or a set of application programs are downloaded from the base computer 30 to the spray controller 18 via the wireless data communications link 32. Next, during step 104, an application program is merged with the operating system software and a material application operation is conducted in accordance with the application program executed by the spray controller 18. During the application operation, the telemetry data is observed at the site of the application equipment as well as the base computer 30. Other operations, including remedial measures, are performed during step 104 in accordance with the application program and the observed parameters.

Finally, the summary data is uploaded from the spray controller 18 to the base computer 30. The transmission step is performed with the aid of the wireless communications link 32. It will be appreciated by those skilled in the art that the monitoring step 104 and the uploading step 106 may be performed at the same time and several times during the course of an application operation. This is especially true when an application operation is being remotely monitored at the base computer 30 via the communications link 32.

In accordance with a particular aspect of the base computer system, the user interface includes graphical user interface facilities for permitting a user to create application programs concerning intended operation of a spray controller. Such application programs are typically required to perform a specific task, such as apply a specific amount of liquid spray material over a field. Once created, the application program may be saved or it may be pre-programmed and stored at the base computer for later use. Such application programs are communicated to the remote spray controllers, and enable monitoring of the operation of such equipment remotely. As explained below, such programs are preferably created via graphical user interface commands. Fig. 5 is one exemplary graphical user interface for programming the base computer 30. This interface is a System Setup interface which enables an operator to readily create or modify a spray controller program that is intended to be downloaded and executed on a remote spray controller. In this manner, the graphical user interface permits an operator to specify desired parameters to program the spray controller with minimal computer/typing skills and without detailed training in, or knowledge of, programming procedures.

In the embodiment shown in Fig. 5, the System Setup interface presents a window-type display which includes various drop-down lists, input fields and buttons to enable user interaction with and programming for the system controller. For the illustrated example, the Setup interface includes a "Units" drop-down list 110 that identifies available system units, such as SI (metric) or English units. The interface also includes a Sensing drop-down list 112 for permitting the user to select flow or pressure. A Regulation drop-down list 114 permits the user to select the configuration of the system, such as Bypass mode. Those skilled in the art will appreciate that various other modes may be selected. Finally, a Speed sensor drop-down list 116 permits the programmer to enter the type of speed sensing that will be employed by the system for the particular task, if any.

The Setup interface also includes various input fields. As shown, a flow calibration value field 118, a ground speed field (measured in p/300 ft) 120, spray

tip and Regulation force input fields 122, 124 may be supplied by the programmer or set to default values. In addition, various calibration input fields are used. These include, by way of example, a pressure sensor reference and pressure sensor output at maximum output current shown as numerals 126, 128. The system interface also includes input fields relating to the Simulated speed, Minimum pressure, Spray tip spacing and Density of material being utilized denoted by numerals 130, 132, 134 and 136. Finally, the interface includes various input fields relating to the spray boom sections being utilized as denoted by numeral 138. In the illustrated example, six spray tips per section are employed.

Finally, the interface includes a drop-down list 140 to permit the user to input the type of communication being employed, such as two-way communication. The interface further includes appropriate controls to permit the user to exit the System setup window.

For monitoring one of a plurality of spray equipment, the base computer is also programmed to display a user interface for permitting real-time observation of the operation of the spray equipment as observed by the spray controller 18. A target rate field 150 displays the programmed spray rate for the present application program. This value is compared to a simultaneously displayed actual rate field 152. A ground speed field 154 displays the present actual speed of the application equipment. There is no target speed since the system adjusts other parameters to maintain the actual application rate in accordance with the target application rate as displayed in the target rate field 150. For example, if the actual rate is too low, not enough material is being applied over a particular surface area for a given ground speed. Therefore, the equipment is either slowed down or the flow rate is increased.

The system pressure field 156 displays the present pressure being applied by the pressure source to the applied material. An instantaneous flow rate field 158 specifies the rate, in volume per minute, at which the liquid spray is being supplied through the main fluid line. In an enhanced version of the present embodiment, each nozzle assembly is equipped with pressure or flow rate sensing

devices to enable the operator to detect clogs or other mechanical defects in the delivery path of the applied material through the individual nozzles or nozzle set (for a nozzle assembly comprising a set of nozzles).

The area coverage rate is based upon the speed of the application equipment and the active width of the spray path. Thus, active width is an important variable during an application operation. This variable can also be used to determine the approximate time, based upon the average speed of the equipment, that will be needed to complete a job having a particular area. The active width is displayed in an active width field 160.

Another set of values of interest to a operator/monitor of a material application operation is the total area covered so far as well as the volume of material applied. This information is provided respectively by an area field 162, determined from the distance traveled times the active spray width, and a volume applied field 164. In addition, a color bar 166 disposed on the user interface includes a set of colored blocks corresponding to the set of available color-coded spray nozzle sizes. That is, the user interface emulates a set of colored blocks corresponding to available nozzle size located on the spray controller. An indicator, such as the indicator arrow located above the color bar 166 in Fig. 6, identifies the currently selected droplet size. Finally, a reset button 168 and up/down arrows 170 enable an operator at the base computer 30 to adjust the target application rate.

Upon completion of a task by the spraying equipment, the base station preferably saves the relevant information concerning the task on a database. This permits historical data concerning the particular performed tasks to be maintained such that later application programs may be tailored to such historical data. Although the database maintained by the base computer may take many forms, one exemplary description of the various database fields may include those fields in Table I below:

Table I

Item	Planned	Actual
Job Number:	1	
Field Name:	J. Doe Home Farm	
Job Description	Spring burndown	
Crop:	Soybeans	
Date:	March 17, 1999	
Job area:	1000 acres	998.6 acres
Target Application Rate:	20 GPA	20.01 GPA
Total carrier needed	20,000 gallons	19981.9 Gal
Tip Capacity:	.5 GPM	
Sprayer Tip Spacing:	20 inches	
Chemical(s) applied:	Roundup and crop oil	
Chemical active ingredient rate:	2 quarts/acre	
Total active ingredient needed:	2000 quarts	1997.2 quarts

In accordance with another particular of the invention, the application programs corresponding to one of a plurality of spray controllers is further presented as an icon or other unique identifier. In this manner, the base station may partition one or more of the spray controllers so that they are executed separately. In this way, the base station may alter the control program and/or monitor a selected spray controller. Similarly, software modules which perform selected functions on the base computer may be presented as icons. This enables

the user to efficiently add or remove functionality through a drag-and-drop operation.

An additional feature of the invention is provided with message communication capabilities to enable inter-process communication between the base computer process and spray controller processes. This is particularly advantageous where multiple spray controllers are being controlled and/or monitored by a base station process. This feature may also be utilized for implementing communication multiple base station processes for controlling and/or monitoring multiple spray controllers. For example, when a request for a particular action to be taken by the base station is issued by one of the plurality of spray controllers, that spray controller may issue a message to the base computer process. Among other things, the message may request the base station to invoke the application program corresponding to requesting spray controller. In the preferred embodiment, such communication may be handled by the base station with message queues. In response to receipt of the messages, the operating software on the base computer will invoke suitable handling software to respond to the request. Typically, the handling software will include further communication to the requesting spray controller to verify that the request was serviced.

Illustrative embodiments of the present invention and certain variations thereof have been provided in the drawings and accompanying written description. The present invention, however, is not intended to be limited to these embodiments. Instead, the invention is intended to cover the disclosed embodiments as well as other implementations and equivalents falling within the scope and spirit of the invention to the fullest extent permitted, as set forth in the appended claims which form part of this disclosure.

WHAT IS CLAIMED IS:

1. A wireless networked spray application system comprising:

a base computer including a central processing unit and a user interface;

a spray application controller located proximate spray application hardware including a set of spray nozzles, the spray application controller being communicatively coupled to receive signals from spray control sensors; and

a wireless communication link facilitating communication between the base computer and the spray application controller, the wireless communication link including a wireless base computer transceiver communicatively coupled to the base computer, the wireless base computer transmitter being configured to transmit data to, and receive data from, a wireless spray application controller transceiver, the wireless spray application controller transceiver communicatively coupled to the spray application controller, the wireless spray application controller transceiver being configured to receive the data from the wireless base computer transceiver and to transmit information received from the spray application controller to the wireless base computer transceiver.

2. The wireless system of claim 1 wherein the base station includes a graphical user interface facilitating monitoring the operation of application hardware via sensor information provided by the spray application controller and transmitted by the wireless spray application controller transceiver to the wireless base computer transceiver.

3. The wireless system of claim 2 wherein the base computer includes diagnostic procedures for analyzing the sensor information.

4. The wireless system of claim 3 wherein the base computer includes remedial procedures for correcting the operation of the application hardware in response to results issued by the diagnostic procedures.

5. The wireless system of claim 2 wherein the sensor information includes instantaneous information relating to the application hardware.

6. The wireless system of claim 5 wherein the instantaneous information comprises flow rate.

7. The wireless system of claim 5 wherein the instantaneous information comprises velocity of a vehicle carrying the application hardware.

8. The wireless system of claim 5 wherein the instantaneous information comprises global positioning system data.

9. The wireless system of claim 5 wherein the instantaneous information comprises summary data concerning the operation of the application hardware over a period of time.

10. The wireless system of claim 1 wherein the base computer includes configuration procedures for creating spray controller programs.

11. The wireless system of claim 1 wherein the base station includes a graphical user interface facilitating creation of sprayer control programs, and procedures for providing the sprayer control programs to the wireless base computer transceiver for transmission to the wireless spray application controller transceiver.

12. The wireless system of claim 1 wherein the user interface of the base computer includes facilities for enabling a user to create control programs via graphical user interface instructions.

13. A method for controlling a remote spray controller with a base station in wireless networked communication therewith comprising

creating an application program at the base station,

downloading the application program from the base station to the remote spray controller through a wireless networked communication link,

monitoring from the base station various operating conditions of the spray controller through said wireless networked communication link, and

uploading from the spray controller to the base station summary data concerning operating conditions of the spray controller through said wireless networked communication link.

14. The method for controlling a remote spray controller as in claim 13 further comprising the step of downloading control instructions from the base station to the remote spray controller in response to the monitoring step.

15. The method for controlling a remote spray controller as in claim 14 further comprising the step of providing a user interface at the base station for creating the application program.

16. The method for controlling a remote spray controller as in claim 15 wherein the user interface is a graphical user interface.

17. A computer-readable medium having computer-executable instructions for a base computer in a wireless communication network to perform a method for communicating with one or more remote spray controllers, the method including the steps of:

presenting a graphical user interface for permitting the creation of an application program at the base station,

establishing a wireless communication link between the base computer and the one or more remote spray controllers,

downloading the application program from the base station to the remote spray controller through the wireless communication link,

monitoring from the base station various operating conditions of the spray controller, and

uploading from the spray controller to the base station summary data concerning operating conditions of the spray controller.

18. The computer-readable medium as in claim 17 further comprising computer-readable instructions for performing the step of downloading control instructions from the base station to the remote spray controller in response to monitoring from the base station various operating conditions of the spray controller.

19. The computer-readable medium as in claim 17 further comprising computer-readable instructions for allocating memory in the computer for creating a database, and for performing the step of storing the summary data concerning operating conditions of the spray controller in the database.

20. A computer-readable medium having computer-executable instructions for a spray controller connected to a wireless communication network to perform a method for communicating with a base computer, the method including the steps of:

presenting a graphical user interface on the spray controller,

receiving from the base computer an application program created at the base computer through a wireless communication link between the base computer and the spray controller,

executing the application upon receipt thereof from the base computer

transmitting from spray controller to the base computer various operating conditions of the spray controller, and

uploading from the spray controller to the base station summary data concerning operating conditions of the spray controller.

21. The computer-readable medium as in claim 20 further comprising computer-readable instructions for performing the step of receiving control instructions from the base computer through the wireless networked communication link.

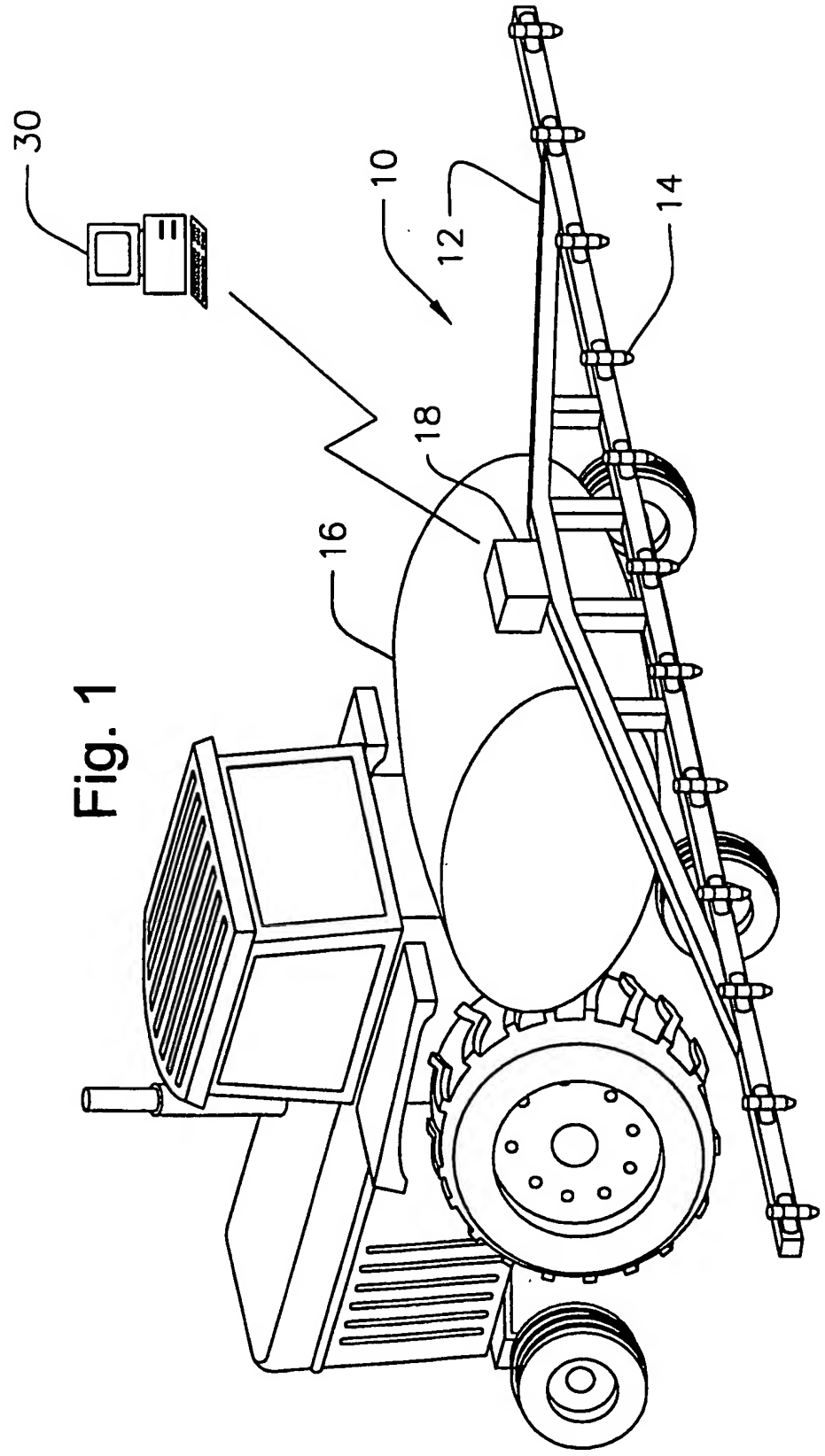

Fig. 1

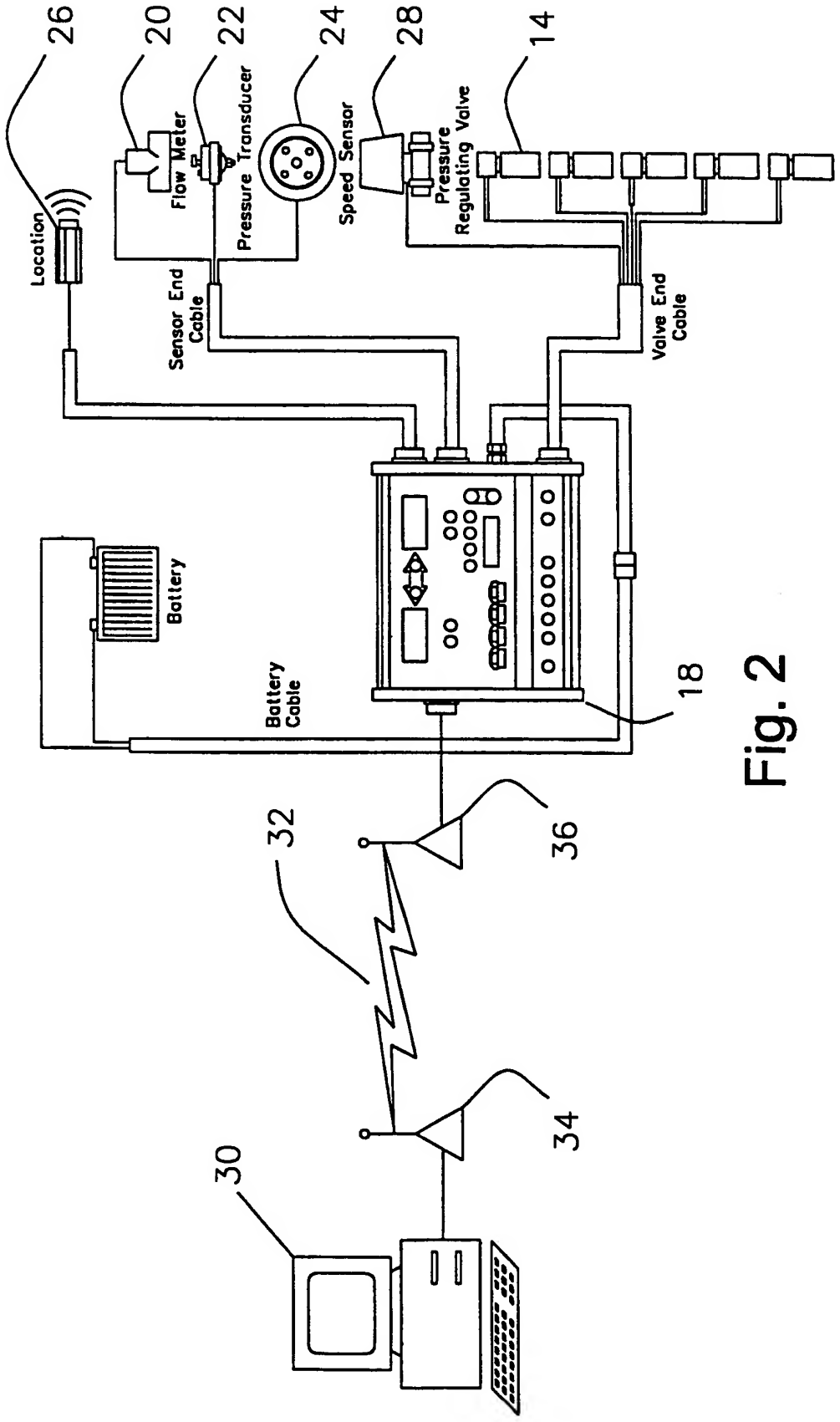
26
20
22
24
28
14
Location
Flow Meter
Pressure Transducer
Speed Sensor
Pressure Regulating Valve
Sensor End Cable
Valve End Cable
Battery
Battery Cable
18
32
36
34
30

Fig. 2

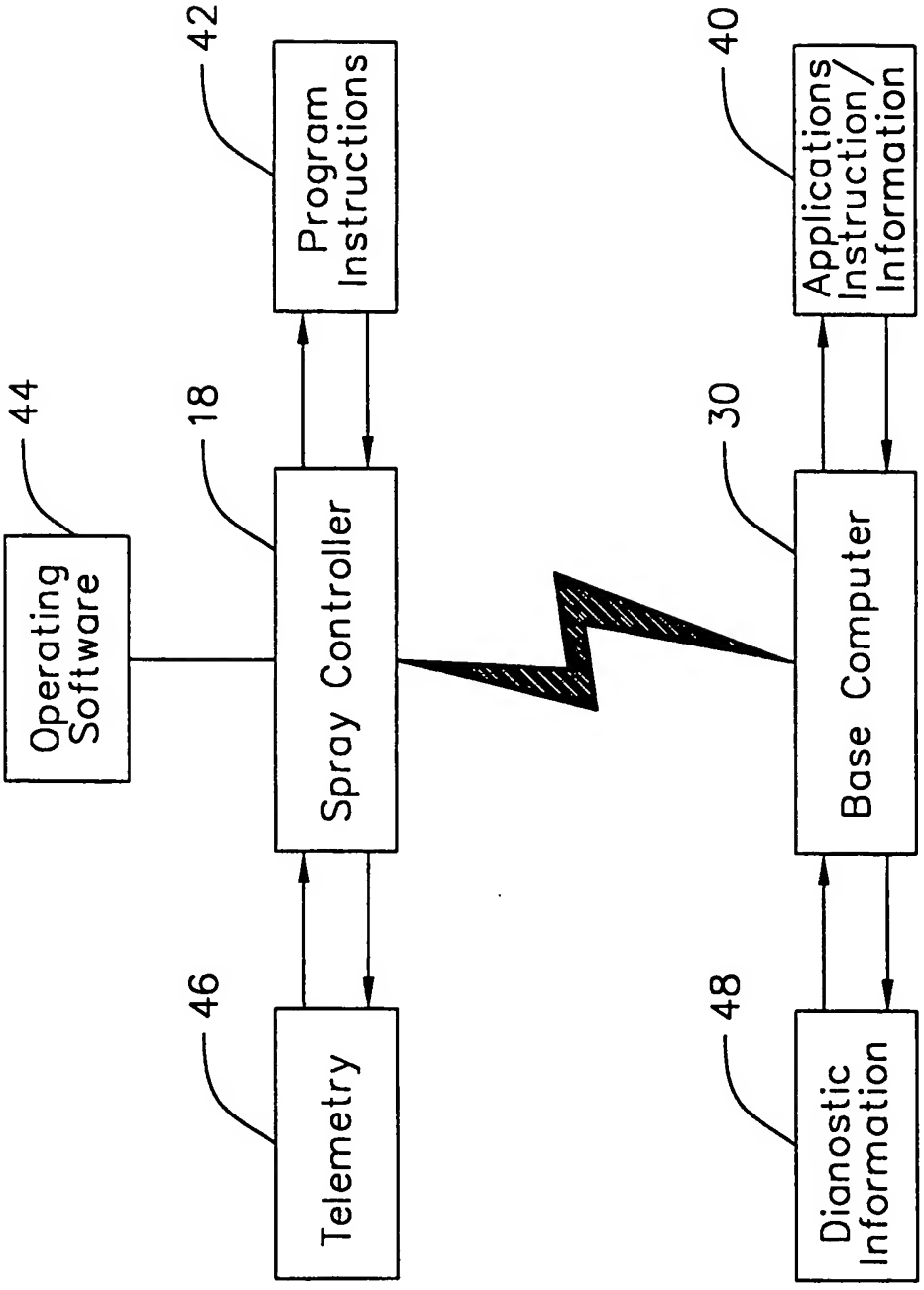
42
Program Instructions
40
Applications Instruction/ Information
44
18
30
Operating Software
Spray Controller
Base Computer
46
48
Telemetry
Dianostic Information

Fig. 3

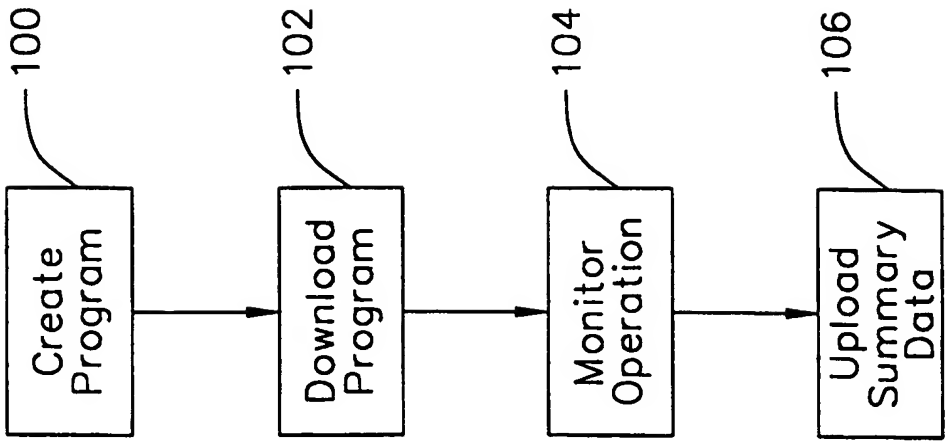
100
Create Program
102
Download Program
104
Monitor Operation
106
Upload Summary Data

Fig. 4

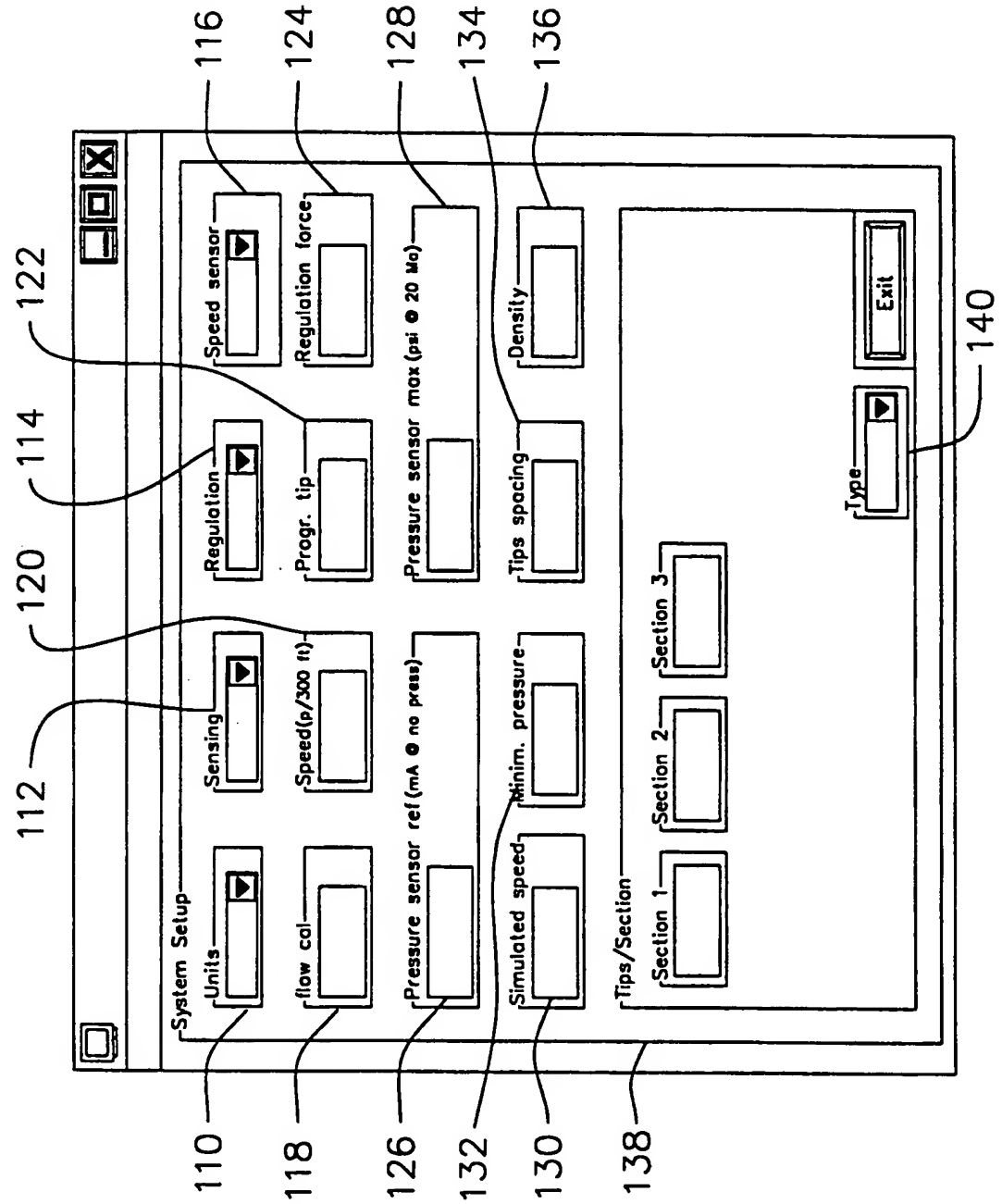
System Setup
Units
Sensing
flow cal
Speed(p/300 ft)
Pressure sensor ref (mA @ no press)
Simulated speed
Minim. pressure
Tips/Section
Section 1
Section 2
Section 3
Regulation
Progr. tip
Pressure sensor max (psi @ 20 Ma)
Tips spacing
Speed sensor
Regulation force
Density
Type
Exit
110
112
114
116
118
120
122
124
126
128
130
132
134
136
138
140

Fig. 5

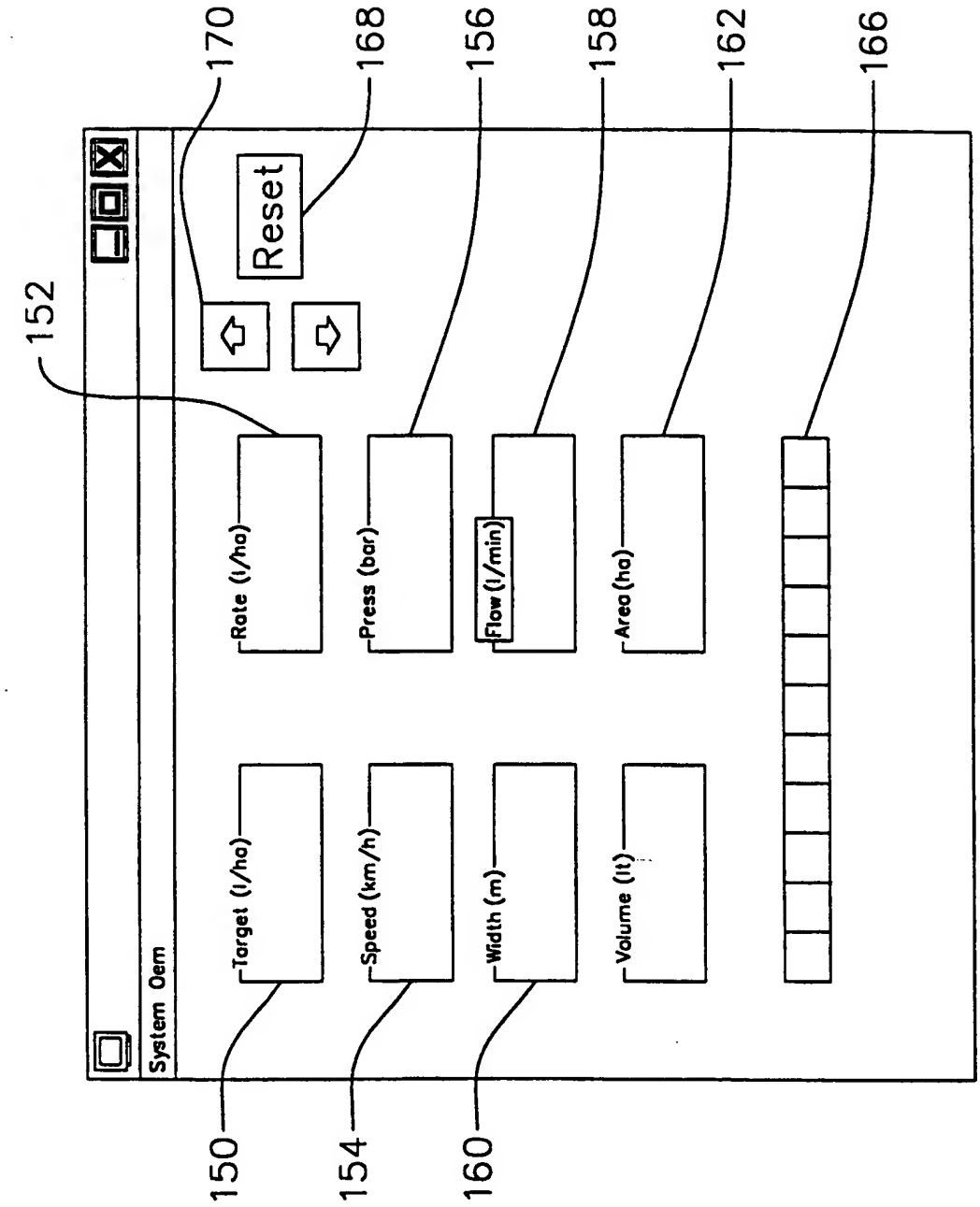
170
168
156
158
162
166
152
Reset
Rate (l/ha)
Press (bar)
Flow (l/min)
Area (ha)
System Oem
Target (l/ha)
Speed (km/h)
Width (m)
Volume (lt)
150
154
160

Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/24338

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :G05D 1/00

US CL :701/2, 33, 50, 213; 239/1, 69

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 701/2, 29, 33, 50, 213; 239/1, 69, 73, 74

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,712,782 A (WEIGELT et al) 27 January 1998, fig. 1 and columns 4-9.	1-21
X, E	US 6,154,699 A (WILLIAMS) 28 November 2000, fig. 1 and columns 4-6.	1-21
A, P	US 6,112,139 A (SCHUBERT et al) 29 August 2000, see the entire document.	1-21
A	US 5,551,524 A (YAMAMOTO et al) 03 September 1996, fig. 2.	1-21
A, P	US 6,061,614 A (CARRENDER et al) 09 May 2000, see the entire document.	1-21

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 14 DECEMBER 2000	Date of mailing of the international search report 11 JAN 2001
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer GARY CHIN Telephone No. (703) 308-1113